

## Forces and Motion

### 5-5 The student will demonstrate an understanding of the nature of force and motion. (Physical Science)

#### 5-5.1 Illustrate the effects of force (including magnetism, gravity, and friction) on motion.

**Taxonomy level:** 2.2-B Understand Conceptual Knowledge

**Previous/Future knowledge:** In the 1<sup>st</sup> grade (1-5.2), students explained the importance of pushing and pulling to the motion of an object. In 3<sup>rd</sup> grade, students explained how the motion of an object is affected by the strength of a push or pull and the mass of the object (3-5.3) and the relationship between the motion of an object and the pull of gravity (3-5.4). In 2<sup>nd</sup> grade (2-5.2), students explained how the poles of magnets affect each other (that is, they attract and repel one another). In 8<sup>th</sup> grade, students will analyze the effects of forces (including gravity and friction) on the speed and direction of an object (8-5.3) and predict how varying the amount of force or mass will affect the motion of an object (8-5.4).

**It is essential for students to know** that a *force* is a push or pull. Forces can make things move faster, slower, stop, or change direction. Different forces (including magnetism, gravity, and friction) can affect motion.

#### *Magnetism*

- A force that acts at a distance and cannot be seen.
- Materials that create this force are said to be magnetic and are called *magnets*.
- The needle of a compass moves because of Earth's *magnetism*.
- When like poles (S-S or N-N) of magnets are near each other, the magnetic force causes the poles to repel, and the magnets push away from each other.
- When opposite poles (N-S or S-N) of magnets are near each other, the magnetic force causes the poles to attract, and the magnets pull toward each other.
- The closer the objects, the greater the magnetic force.
- The magnetic force is greatest at the poles of magnets.

#### *Gravity*

- A pull that attracts objects to each other.
- This attraction is not noticeable unless one of the objects is very large, for example a planet, a moon, or the Sun.
- The force of gravity between Earth and anything on it is extremely noticeable because the mass of Earth is so large. The pull of Earth's gravity makes any object fall to the ground.
- As the Moon goes around Earth, its gravity pulls on Earth causing water in the oceans to move toward the Moon.
- Earth's gravity also pulls on the Moon. This force of gravity keeps the Moon moving around Earth.
- Similarly, the pull of the Sun's gravity keeps Earth moving around the Sun.

#### *Friction*

- The force that opposes motion between two surfaces that are touching.
- The effect of friction can be observed as an object slides across a surface and slows down.
- The rougher the surfaces are, and the harder the surfaces press together, the more friction there will be.

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- Friction can be reduced by using *lubricants*, for example motor oil, wax, or grease, by making surfaces smoother, or by using rollers.
- Friction occurs in liquids and gases as well as between solids.
- Without friction, it would be very hard to slow or stop the motion of objects.

**It is not essential for students to** know the quantitative relationships involved in forces affecting the motion of objects.

#### **Assessment Guidelines:**

The objective of this indicator is to *illustrate* the effects of force on motion; therefore, the primary focus of assessment should be to give or use illustrations, including pictures, diagrams, or word descriptions, of how forces (including magnetism, gravity, and friction) affect the motion of objects. However, appropriate assessments should also require students to *summarize* information about how magnetism, gravity or friction affect the motion of objects; or *recognize* how these forces can affect the motion of objects.

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#### 5-5.2 Summarize the motion of an object in terms of position, direction, and speed.

**Taxonomy level:** 2.4-B Understand Conceptual Knowledge

**Previous/Future knowledge:** In 1<sup>st</sup> grade, students identified the location of an object relative to another object (1-5.1) and illustrated ways in which objects can move in terms of direction and speed (including straight forward, back and forth, fast or slow, zigzag, and circular) (1-5.4). In 3<sup>rd</sup> grade, students identified the position of an object relative to a reference point using position terms and a distance scale or measurement (3-5.1) and compared the motion of common objects in terms of speed and direction (3-5.2). Students will further develop these concepts in 8<sup>th</sup> grade (8-5.2) where they will develop the concept of speed quantitatively.

**It is essential for students to know** that motion is described in terms of position, direction, and speed as follows:

#### *Position*

- The *position* of an object is its location relative to another object (the reference point) for example “above”, “below”, “beside”, “behind”, “ahead of” plus the distance from the other object.
- The distance (length) from the reference point changes when the object moves.

#### *Direction*

- *Direction* of motion is the course or path that an object is moving and can be determined by reading a compass using the terms “north”, “south”, “east”, or “west.”
- Direction can also be described using the terms “right”, or “left,” “forward,” or “toward” relative to another object, or “up”, or “down” relative to Earth.

#### *Speed*

- A measure of how fast an object is moving.

**NOTE TO TEACHER:** Students should be able to measure the distance specific objects move in a given time. They can compare the relative speeds of different moving objects determining which is moving faster or slower.

**It is not essential for students to know** the concept of velocity (both speed and direction), or the concept of acceleration (changing speed). Students do not need to calculate speed.

#### **Assessment Guidelines:**

The objective of this indicator is to *summarize* the motion of an object in terms of position, direction, and speed; therefore, the primary focus of assessment should be to generalize major points about motion relative to position, direction, and speed. However, appropriate assessments should require students to *identify* the terms of position, direction, and speed and use them to describe motion; *illustrate* motion in terms of position, direction, and speed using drawings, diagrams, and word descriptions; or *interpret* a diagram of an object changing position over time in order to determine the speed of the object.

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#### 5-5.3 Explain how unbalanced forces affect the rate and direction of motion in objects.

**Taxonomy level:** 2.7-B Understand Conceptual Knowledge

**Previous/Future knowledge:** In 1<sup>st</sup> grade (1-5.1), students explained the importance of pushing and pulling to the motion of an object. In 3<sup>rd</sup> grade, students compared the motion of common objects in terms of speed and direction (3-5.2) and explained how the motion of an object is affected by the strength of a push or pull and the mass of the object (3-5.3). Students have not been introduced to the concept of unbalanced forces or rate of motion of objects in previous grade levels. Students will further develop the concepts of the effect of balanced and unbalanced forces on an object's motion in terms of magnitude and direction in 8<sup>th</sup> grade (8-5.6).

**It is essential for students to** know that unbalanced forces change the rate and direction of the motion of objects.

- Several forces can act on an object at the same time.
- Sometimes forces are balanced which means that they are equal in strength but opposite in direction.
- Balanced forces do not change the motion of objects only unbalanced forces cause changes in motion.
- An unbalanced force is one that does not have another force of equal magnitude and opposite direction off-setting it.
- *Rate of motion* is the speed of the object or how fast or slow the object is moving.
- Unbalanced forces can change the rate or direction of motion of an object in different ways:

#### *Object at rest*

- If an unbalanced force acts on an object at rest the object will move in the direction of the force.
- A stronger force (push or pull) will make it move faster.

#### *Object in motion*

- If an object is moving, an unbalanced force will change the motion of the object in different ways depending on how the force is applied. The unbalanced force may speed the object up, slow it down, or make it change directions.
  - If the force is applied in the same direction as the object is moving, the object will speed it up.
  - If the force is applied in the opposite direction as the object is moving, the object will slow it down or stop it.
  - If the force is applied to the side of the moving object, the object will turn.

**It is not essential for students to** know the difference between speed and velocity, or the concept of acceleration.

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### **Assessment Guidelines:**

The objective of this indicator is to *explain* how unbalanced forces affect the rate and direction of motion in objects; therefore, the primary focus of assessment should be to construct a cause-and-effect model of how the rate and direction of motion is affected by unbalanced forces. However, appropriate assessments should also require students to *identify* the meaning of unbalanced forces, rate, and direction of motion; *summarize* information about unbalanced forces and how they affect rate and direction of motion; or *illustrate* with drawings, diagrams, or word descriptions the effects of unbalanced force on an object.

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#### 5-5.4 Explain ways to change the effect that friction has on the motion of objects (including changing the texture of the surface, changing the amount of surface area involved, and adding lubrication).

**Taxonomy level:** 2.7-B Understand Conceptual Knowledge

**Previous/Future knowledge:** Students have not been introduced to the concept of friction in previous grade levels. Students will further develop the concept of friction in 8<sup>th</sup> grade (8-5.3)

**It is essential for students to** know that friction is a force produced when objects are in contact with each other. Friction is a force that acts against motion. The following variables influence the affect of friction:

##### *Texture of the surface*

- *Rough surfaces* tend to create more friction.
- *Smooth surfaces* tend to create less friction.

##### *Amount of surface area*

- The amount of surface area affects the friction between objects in liquids and gases.
- The amount of surface area affects the friction on a moving object under the following circumstances: air resistance (such as the size of a parachute) or the resistance of an object as it glides through water (such as a boat).
- The amount of surface area in contact usually does not affect friction between two solids.

##### *Lubrication*

- *Lubrication*, for example oil or grease, reduces the effects of friction.
- Without lubrication, moving parts of machines would slow down or stop very quickly.

**It is not essential for students to** know why these factors affect friction.

#### **Assessment Guidelines:**

The objective of this indicator is to *explain* ways to change the effects of friction on the motion of objects; therefore, the primary focus of assessment should be to construct a cause-and-effect model of the ways to change the effects of friction on motion including those listed in the indicator. However, appropriate assessments should also require students to *recognize* factors that affect friction; *illustrate* a diagram of objects moving to determine which factors are increasing friction to slow down or stop the motion; *summarize* major points about the factors that affect friction with their increasing or decreasing the effects; *infer* which factors are increasing or decreasing friction to slow down or speed up the motion of objects.

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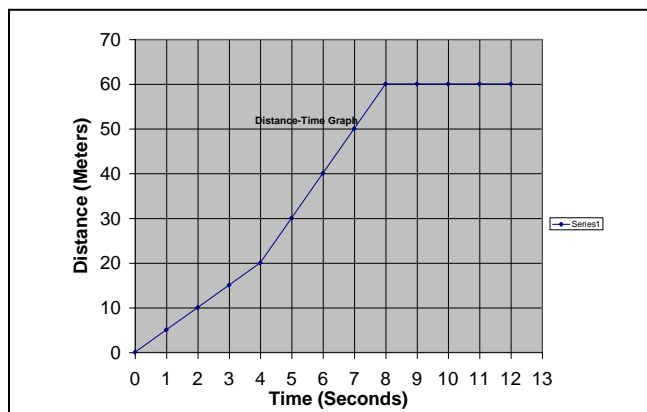
**5-5.5 Use a graph to illustrate the motion of an object.**

**Taxonomy level:** 3.2-B, C Apply Procedural and Conceptual Knowledge

**Previous/Future knowledge:** Students have not been introduced to the concept of using a graph to illustrate motion of an object in previous grades. Students will further develop the concepts of graphing motion in 8<sup>th</sup> grade (8-5.1).

**It is essential for students to** construct a distance-time graph to illustrate the motion of an object. For example, given the following data collected from a moving object:

Time (Sec)	Distance (meters)
0	0
1	5
2	10
3	15
4	20
5	30
6	40
7	50
8	60
9	60
10	60
11	60



Distance-Time Graph

To construct a distance-time graph, follow the correct procedures for producing a graph:

- Correct placement of dependent and independent variables (DRY-MIX)
- Correct labeling of the axes
- Title the graph
- Correct placement of intervals

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**It is essential for students to** interpret the motion of an object from studying a distance time graph, including:

- The total distance that the object has traveled after a certain amount of time
- The distance that the object travels during a particular time interval
- Determine if the object is moving or stationary during a particular time interval
- Compare the motion of the object during two time intervals (Based on the shape of the graph, is the object moving faster or slower?)

**It is not essential for students to** know how to construct the graph of time versus position from the data. They must only interpret the graph at this grade level as illustrating speed, faster speed, slower speed, and stopped motion.

#### **Assessment Guidelines:**

The objective of this indicator is to *use* a graph to illustrate the motion of an object; therefore, the primary focus of assessment should be to apply a procedure of using a graph to illustrate of the motion of objects. However, appropriate assessments should also require students to *infer* from the shape of a distance time graph whether an object is moving or not; or *compare* distance-time graphs to determine which object is moving faster.

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#### 5-5.6 Explain how a change of force or a change in mass affects the motion of an object.

**Taxonomy level:** 2.7-B Understand Conceptual Knowledge

**Previous/Future knowledge:** In 3<sup>rd</sup> grade (3-5.3), students explained how the motion of common objects is affected by the strength of a push or pull and the mass of the object. They have not been introduced to the concept of a change in force or mass affecting the motion of an object in previous grades. They will further develop these concepts in 8<sup>th</sup> grade (8-5.4) when students will predict how varying the amount of force or mass will affect the motion of an object.

**It is essential for students to** know that the motion of an object can be affected by a change in force or a change in mass

#### *Force*

- If there are two objects with the same mass and one is acted on by a greater force than the other, the one acted on by the greater force will have the greatest change in speed.
- It will speed up the most or slow down the most in a given amount of time.

#### *Mass*

- If there are two objects, one with a greater mass than the other, and the same amount of force is applied to each object, the object with the lesser mass will have the greater change in speed.
- It will speed up or slow down more in a given amount of time.
- It is harder to change the speed of the object with the greater mass than the object with the lesser mass.

**It is not essential for students to** know that the change of speed of an object is called acceleration. Students also do not need to know the quantitative relationships among mass, acceleration, and force. Neither do they need to know the relationship between mass and inertia.

#### **Assessment Guidelines:**

The objective of this indicator is to *explain* how the motion of an object is affected by a change in force or mass of an object; therefore, the primary focus of assessment should be to a construct cause-and-effect model of how these factors affect motion of an object. However, appropriate assessments should also require students to *summarize* the effect on motion that a change in force or mass causes; *infer* from the factors whether they increase or decrease the rate of motion; *predict* how a given factor will affect the rate of motion; or *recognize* which factors increase rate of motion and which decrease rate of motion.